FB12

REGIONAL PROJECT OUTLINE

ENGINEERING SYSTEMS

FOR COTTON PRODUCTION

August, 1968

Cooperators: The Agricultural Experiment Station of Alabama, Arizona, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas, and the USDA Agricultural Research Service, Agricultural Engineering Research Division

REGIONAL PROJECT OUTLINE

Project Number:

Duration: July 1, 1969 to June 30, 1973.

Title: Engineering Systems for Cotton Production

OBJECTIVES:

A. Develop a computer simulation model of the generalized cotton production system for evaluating aspects of specific systems and subsystems.

B. Develop or improve cotton production subsystems, while simultaneously providing information and data for objective A.

C. Evaluate cotton production subsystems by means of simulation techniques using the model developed in A and the subsystems developed in B, to (1) establish their relative importance and (2) coordinate research efforts under objective B.

PROCEDURE: Research responsibilities will be assigned to participants and research will be done in such a manner and be of such nature that it will have a high transfer value from the place of execution to other locations in the region. Laboratory-type control and instrumentation will be utilized to the fullest practicable extent to control variables. In field experiments, the best-known agronomic practice, varieties,

water control, fertilization, chemicals, and timing of cultural practices will be used to minimize variations; and accepted statistical design and analysis procedures will be employed. The above practices will be reported and in addition, soil type and fertility level will be reported where yields are taken. Duplication of effort will be avoided in the major climatic areas and soil types except for verification of transferability. Research techniques will be coordinated and information will be pooled.

The following research responsibilities are assumed:

A. Develop an analytical model by functional analysis technique for the purpose of describing the overall cotton production system from pre-planting to post harvest. This preliminary model will serve to identify and orient subsystems within the overall system. A first order computer simulation model will then be developed. It will be a generalized model capable of encompassing all specific production models in the region, and will be used for studying engineering aspects of the subsystems and evaluating specific production systems. The responsibility for developing these models will be assumed by four states, and the models will be made available to all stations for evaluating the systems and subsystems described in procedure B. The following contributors will collaborate in model design:

1. The Biological and Agricultural Engineering Department of the North Carolina Agricultural Experiment Station, Raleigh, North Carolina.

2. The Agricultural Engineering Research Division, ARS, in cooperation with the Agricultural and Biological Engineering Department of the Mississippi Agricultural Experiment Station and Mississippi State University, State College, Mississippi.

3. The Agricultural Engineering Department of the Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma.

4. The Agricultural Engineering Department of the Arizona Agricultural Experiment Station, Tucson, Arizona.

B. Subsystems for the modification of environmental factors affecting growing conditions and improved systems for harvesting, handling and storage of cotton will be developed, and specific values will be determined for use in the complete system analysis. The inter-relationship of plant physical properties, growth requirements, environmental control mechanisms, and machines will be considered in the development of subsystems as follows:

1. Seed and rootbed environment subsystems.

   Measurements: A minimum of the following data will be recorded in accordance with committee standards. Additional data found to be desirable for model use will be specified and other data may be taken as needed for certain tests.

   Seedbed preparation - Moisture content, at time of tillage, field capacity, cone penetrometer under row after planting, emergence counts, surviving plant population, soil type, fertility level, and yield.

   Planting - Soil temperature, soil moisture content surrounding seed, soil strength over seed, emergence rate, total emergence, and surviving population.

a. Strip or zone tillage including controlled traffic

Alabama: Develop a system of controlled field traffic and establish engineering design criteria for machines to accomplish the desired controlled field traffic in cotton production on typical economic cotton soils of the Southeast. In addition to standard minimum measurements, the controlled field traffic patterns will be evaluated to determine the effects of traffic on soil physical properties, root proliferation, water use efficiency, yield and cost of cotton production.

Oklahoma: Evaluation of new, existing, and experimental tillage tools will be conducted on a field basis and in a laboratory soil bin facility on economic cotton soils of Oklahoma and Western Texas. Field work will be done in a cotton production system and evaluation will be based upon standard measurements. Laboratory evaluation will be used to determine the effect of tool configuration on forces and energy requirements associated with the tool's use.

b. Bed shaping for precision and timeliness of operations

Arkansas: Develop and evaluate bed shaping equipment for mid-south conditions. Evaluate size, shape, height, time of shaping, and other variable inputs on typical regional soil types. Make standard measurements. Coordinate with weather records. Effects on improvement in cultivation and chemical application efficiency will be noted.

Georgia: The most effective combination of soil preparation and method of herbicide incorporation will be determined for cotton soil types typical in the Southeastern Piedmont and Coastal Plains. Preparation methods will include shaped and unshaped beds. Any equipment necessary for this will be acquired or developed. The distribution

pattern of the herbicide will be measured. In addition to standard measurements, weed control, boll size, seed index and fiber characteristics will be recorded.

Texas (College Station): Develop an effective means of constructing and maintaining precision control surfaces on both light and heavy cotton soils, which can be used effectively for providing precise control over the vertical and lateral movements of machines used in planting and post-planting operations, with special emphasis on seed and root environment.

c. Crop residue management

ARS, AERD & Mississippi Station (State College and Stoneville): Optimum limits in size of cut and burial will be established with respect to rate of decomposition and effect on succeeding cultural practices in two typical regional soil types. Design criteria for disposal machines will be developed and integrated with cultural practice subsystems.

d. Equipment for measuring seed zone environment

North Carolina: Equipment will be developed for rapid field measurement of environmental factors, and figures of merit will be developed for use in the simulation model.

2. Metering, placement, and physical characteristics of cotton planting seed.

a. Precision seed selection and metering

Texas (College Station): Develop physical methods of seed selection and evaluate the effects of certain physical properties of seed upon germination, emergence and plant performance.

ARS, AERD & Texas Station (Lubbock): Develop precision seed metering equipment to place single seed at precise spacings in the row. Compare with regular drill planting by standard measurements and by measuring effects on harvesting and quality.

b. Seed placement, covering and compaction

ARS, AERD & Texas Station (Lubbock): Measure seed zone environment in shaped beds. Relationships of seed depth, seed quality, temperature, moisture, emergence, plant development, yield and quality of fiber and seed will be studied.

ARS, AERD, & Mississippi Station (Stoneville): Laboratory and field tests will be conducted to determine effect of soil compaction, seed rate, seed placement, moisture, temperature, and other environmental factors on seedling emergence and growth under Mid-South climatic and soil conditions. Environmental control chambers will be used in laboratory tests to control environmental factors and the relationships between these factors and variations in planting methods can be evaluated.

c. Automatic planter monitoring and control

ARS, AERD & Mississippi Station (Stoneville: Planters will be operated in the laboratory using variable speed motors and sufficient transparent plastic will be used so that all moving parts can be monitored with high speed photography. Pressure and micro-switches will be mounted on the planter to develop a complete system for monitoring and control of seed metering, flow level, and drop.

North Carolina: Transducers and prototype servo controls will be developed for sensing and controlling planter depth and presswheel compaction pressure as a function of the moisture content of the soil.

d. Standardization of planter components for regional adaptability

Georgia: Planter components will be studied and modified for possible improvement in plant emergence. Factors determined from previous regional work will be combined into the design of a planter, with options suitable for use across

the cotton belt. This planter will be field tested at various locations. Standard data will be taken plus boll size, seed index and fiber characteristics.

3. Plant and environmental control mechanisms and materials application.

   a. Pest control

   Arkansas: Evaluate mechanized chemical-mechanical weed control systems on typical regional soils for optimum weed control and minimum costs (data to fit computer production model).

   Louisiana: (1) Determine the characteristics of flame required to obtain the optimum heat application for maximum weed control through a study of the physical properties influencing heat transfer in the plants. The temperature distributions in the plants will be related to physical properties of the plants and flame. The heat requirements for killing plants will be determined and used as a basis for the design or improvement of flame burners and their use. (2) Determine new and improved methods to obtain maximum weed control including a study of the utilization of extended heat exposure, electrical power, vibrations and other sources. (3) Determine the energy utilization required to obtain the optimum conditions for maximum weed control and incorporate the results into the regional model cotton production system. Records of power requirements, labor, fuel, and maintenance costs will be included in this analysis.

   Georgia: Described under 1c.

   ARS, USDA & Mississippi Station (Stoneville): Design and improve weed control equipment. New and old methods of weed control including thermal, mechanical, and chemicals in all phases of the crop cycle will be researched for more effective application of the complete system of production. Techniques for measuring efficiency of equipment shall be developed. Final

analysis will include biological measurements made in cooperation with weed scientists.

ARS, AERD, Boll Weevil Research Laboratory (State College, Mississippi): (1) Develop an experimental droplet generator for field use and determine the droplet size of ULV sprays for effective insect control and maximum deposit in a treated area. A rotating disc sprayer, used with various collecting devices for satellite droplets, will be tested as a possible field generator of a narrow spectrum of droplet sizes. Using ULV sprays, this or similar equipment will be used to evaluate effects of droplet size on insect control, deposition, and drift. (2) Develop equipment for destroying fallen cotton squares. Work will be directed at improving pickup efficiency of prototype machines and redesigning equipment so that treatments can be made through large, fruited plants. Evaluation will be by pickup efficiency, population reduction of insects in fallen squares, and overall entomological control.

ARS, AERD & Texas Station (Lubbock): Develop controlled-depth soil incorporation equipment for pre-plant herbicides on beds for irrigated cotton. Integrate with planting system for precise control of seed and treated soil relationship. Evaluation will be by standards under B.1., weed control and yield.

b. Harvest aid application

Standard environmental measurements will be taken to develop data for use in the model as follows: (1) accumulated heat units, (2) soil moisture balance, (3) solar radiation, and (4) evaporation.

Louisiana: Determine the techniques required for the effective application of harvest-aid chemicals for reduced trash in the harvested cotton and improved conditions for harvesting. Nozzle requirements for obtaining desired spray characteristics for applying harvest-aid chemicals will be determined.

Oklahoma: Develop and condition inputs describing thermal defoliation in cotton production systems. A proto-type thermal defoliator will be used to establish the effects of humidity, temperature, amount of light, and plant condition on application effectiveness. Cotton quality, harvester performance and cost will be determined when harvesting is done at varying intervals after thermal application.

South Carolina. Develop a rational model for optimum defoliation and harvest scheduling in the Southeast, based upon environmental history. The model will be based upon relevant environmental factors listed above. Field plots will be planted at different dates to expose cotton plants to different environmental histories.

c. Mechanics of materials application

Louisiana: Determine the characteristics of sprays required to obtain the optimum herbicide application for maximum weed control with the aid of a study of the characteristics of spray nozzles in the production of certain types of droplets. The desired types of droplets are to be determined for a specific spray application.

Tennessee: Develop methods to apply ultra-low volume pesticides to specific plant parts and ground with ground equipment; and establish sprayer component specifications for accurately metering and dispensing concentrated chemicals for a chemical control program. Evaluation will be by weed control, and by field and caged boll weevil and worm control.

Alabama: Determine the distribution patterns required for effective plant and leaf coverage when applying agricultural chemicals with ground spray equipment. Distribution patterns will be determined through the use of dyes, chemically sensitive cards, and fluorescent tracers and will be correlated with plant response to establish the most effective distribution patterns

4. Physical characteristics of cotton plants as they relate to harvesting efficiency and product quality.

   a. The influence of cultural practices and plant-altering techniques on the harvesting properties of plants

      ARS, AERD & Mississippi Station (Stoneville): (1) The influence of hill spacing and plants per hill on plant size and shape and subsequent harvester efficiency and fiber quality will be determined for given varieties planted on specific dates as required to complete data from previously normalized data. (2) The most effective time for complete or bottom-defoliation applications combined with once and twice-over harvesting operations will be determined for given harvester type and variety. Final evaluation will be based on net returns considering costs of plant-altering and harvesting treatments. (3) The effectiveness of other chemicals such as wilting agents and growth regulators on harvester performance, yield, and quality will be investigated. Type of chemical, rate and time of application, and effective harvest date will be considered.

5. Machine related factors affecting field harvesting efficiency and quality.

   a. Identification and reduction of sources of contaminants in machine harvested cotton

      ARS, AERD & Mississippi Station (Stoneville): Sources and types of trash in spindle-picked cotton will be identified through field and laboratory studies. The manner in which the types of trash are entangled with cotton fiber in the harvester will be studied with high speed photography and motion analysis projection. Modifications will be made in the harvesting and handling components to reduce trash contamination.

Oklahoma. The cleaning components of cotton harvesting equipment will be evaluated in a harvesting system. Existing and experimental cleaning components will be operated under field, or simulated field conditions, and evaluated on their ability to remove trash components in harvested cotton. The effect on cotton quality, efficiency of cleaning, and capacity will be determined.

ARS, AERD & Texas Station (Lubbock): A burr extractor will be designed with the aid of a computer model. A prototype extractor will be built and tested, along with presently-available extractors, on stormproof, stripped cotton. Evaluation will be based on amount and type of material extracted, ease of operation and maintenance, and the resultant economics.

b. Determination of effects of field layout, row arrangement, and conservation practices

Alabama: To determine the influence of field configuration, field size, row arrangement and length, and erosion control structures on field machine efficiency and capacity. Total field time, turning time, service and adjustment time, down time and other non-productive time will be evaluated also.

ARS, AERD & Texas Station (Lubbock): Automatic steering control will be developed for cotton production equipment. Row patterns and shapes will be modified to facilitate automatic guidance. Field efficiency, time and man-power requirements for harvesting and other cultural operations will be evaluated.

c. Exploration of new ~~principals~~ les of harvesting

ARS, AERD & Mississippi Station (Stoneville): Experimental machines supplied by private industry will be evaluated on a limited scale based on performance efficiency and quality of harvested product.

d. Harvester modification

ARS, AERD & Mississippi Station (Stoneville): (1) Modifications to components of commercially available machines will be accomplished and field tested for their effects on performance and cotton quality. Components in addition to those already available will be constructed in attempts to improve performance or quality. Principal quality factors considered will be trash content and seed damage with subsequent seed coat fragment contamination of the ginned lint. (2) In anticipation of increased picker speeds to improve economic efficiency (reduced cost per bale), the best combination of spindle speed, ground speed, picker efficiency, and harvested quality will be determined. Pickers will be modified so that spindle speeds may be varied independently of ground speed. Yields, plant spacing, and varieties will be considered in all cases.

6. Field handling and storage

a. Determination of physical properties and behavior of mechanically-harvested cotton as related to field handling and storage

ARS, AERD & Mississippi Station (Stoneville): Factors which influence the design of a seed cotton storage container will be identified and their inter-dependence determined. Basic factors already identified include thermal diffusivity, specific heat, and heat of respiration. The variability of each of these factors with such variables as moisture content, seed cotton density, seed/lint ratio, and micro-organism infestation will be determined.

ARS, AERD & Texas Station (Lubbock): Pressure-density relationships will be determined for seed cotton at various moisture contents. Data will be obtained on lint and seed quality relationships.

b. Integration of new concepts in materials handling into more efficient systems of harvesting and handling from the cotton plant to the gin

ARS, AERD & Mississippi Station (Stoneville): Seed cotton handling from the plant to the picker basket will be covered partially under subsystem B.5.a. The interaction between handling, cleaning, and ginning requirements will be investigated. Picker modifications aimed at increased cleaning action during this stage of handling will be made.

Different methods of conveying cotton from the spindles to the basket will be investigated from the standpoint of reduced seed damage and increased cleaning action. Data obtained from this and section B.6.a. will be used to design more efficient handling systems from the field to the gin.

Oklahoma: Develop and evaluate a prototype handling system which incorporates mechanical unloading of cotton wagons, baling of seedcotton in need of temporary storage, and mechanical conveying of all cotton into the gin plant. Principal criteria of evaluation will be maintenance of cotton quality and reduction of handling costs.

ARS, AERD & Texas Station (Lubbock): Data obtained from section B.6.a. will be used to develop a packaging unit for seedcotton harvested by the stripper-type harvester. Different materials, equipment, and techniques will be studied for possible use in developing a more efficient handling system from the field to the gin.

C. Application of the simulation model

The simulation model will be used to evaluate relavence of existing and proposed subsystems including combinations of machines, cultural practices, scheduling of

operations, and environmental interactions. Where additional or supporting data are required, responsibility for its collection will be assumed in one of the following ways. (1) Participants will voluntarily assume responsibility for problems commensurate with their resources and interest. (2) Other necessary assignments of responsibility will be made on an equitable basis by the Technical Committee.

The first step in analyzing existing subsystems will be made by normalizing data developed by past research under the S-2 project (assembling weather, soil classification, cultural practices, machine operations and production output data for computer retrieval). This responsibility has been assumed by the Agricultural Engineering Research Division, ARS, in cooperation with the Agricultural and Biological Engineering Department of the Mississippi Agricultural Experiment Station and Mississippi State University, State College, Mississippi.

The four states having responsibility for developing the overall simulation model shall assume responsibility for evaluating subsystem data and will develop specifications for the data needed.

The representatives of the four stations collaborating in the model design will work with the Executive Committee and the Coordinator as a Coordinating Committee. They

will meet at such times as necessary during the year in addition to annual meetings of the Technical Committee. These meetings will be open to any Technical Committee member.

This project shall cooperate with the Western Regional Project W-99 by exchanging annual reports and other information, through periodic visits by the Coordinator to the projects in the Western Region, by holding occasional joint technical committee meetings, and by inviting representatives of the W-99 project to attend this project's annual technical committee meeting.

JUSTIFICATION: Approximately 80% of the U.S. cotton crop is grown in that part of the cotton belt lying in the southern region from Texas and Oklahoma on the west to the Atlantic coast on the east. This amounted to about 12,000,000 bales annually prior to 1966, and has amounted to about 6,500,000 bales in 1966 and 1967 under reduced acreage and unfavorable crop conditions. (11)*. Cotton will continue to play a vital role in the agricultural economy of the region if it can compete effectively with synthetics and foreign production. The present cost of producing cotton in the U.S. is such that additional engineering research is necessary to enable the farmer to produce our needs and maintain the economy of the region.

*Literature citations listed on page 24.

In 1965, the average cost of producing a pound of lint was 27.3 cents in the United States. The average price received was 28.4 cents. In the Southeast, costs ranged from 27.3 cents to 31.3 cents and the median was 29.2 cents per pound. The median price received was 29.0 cents. In the South Central area (Mississippi Delta to the Texas High Plains) costs ranged from 24.7 cents to 29.9 cents, and the median was 26.4 cents. The median price received was 27.3 cents. (5)

This same report also shows that research has provided the technology to virtually eliminate hand labor in cotton production. Reduction in production costs, however, has not always accompanied reductions in labor. This has been due to the increased cost of equipment and materials required, and in some cases to the piecemeal and unguided adoption of new techniques. Although research has resulted in the development of efficient tools, techniques, and materials for many of the component parts of production operations, very little Beltwide effort has been devoted to the development of complete engineerying systems of production for optimum efficiency under varying conditions.

An engineering systems approach will enable researchers to tailor existing technology as well as new developments into more efficient cotton production systems. No single state has the resources to develop the necessary simulation model to optimize production systems. The successful design and utilization of an optimum model will require research data on all phases of production and harvesting. Because past research in this problem area has been done on a regional basis, each state has only a fraction of the total research data required for a complete system. It would be uneconomical for any one state to generate all the additional research data that will be required to develop an optimum system for any location. The cost of developing a model that can be used throughout the entire region should be relatively little more than for the development of a model to fit only one state or area.

A simulation model will help direct research efforts by directing attention to gaps in information needed for a complete system. The proposed work will supplement recent research and enhance that underway by assigning responsibilities and providing regional planning and analysis techniques. Researchers should be able to analyze existing systems as well as subsystems and determine the needs for further improvements. New developments can then be analyzed as they fit the model system.

The biological and engineering facets of cotton production are inter-dependent. Guidance of soil scientists, physiologists, plant breeders, entomologists, pathologists, economists, and others is essential to the success of this research project. This is to say that care will be taken in this research on engineering systems to utilize the recommendations of related disciplines insofar as applicable to this work.

Related Current Research: Presently, work is underway in several state and USDA projects on the development of improved subsystems for seedbed preparation, planting, pest control, harvesting, and handling. Most of this work contributed to the S-2 project. As a result of this and previous engineering work, improvements are being made in many engineering phases of cotton production. With one exception, however, there are no formal systems analysis techniques being used on any of these engineering projects to combine improvements into optimized systems of cotton production. The exception is an Arizona Agricultural Experiment Station project on the design of a cotton production model. (4) Preliminary work has been done there in optimum scheduling of equipment and cultural practices based on plant development. The Arizona project will be a part of this proposed regional project.

This project will augment and strengthen engineering research on cotton production by providing a systems approach

to more effectively combine improvements into overall production systems. This will help optimize production to the benefit of the producer, processor, and consumer.

PREVIOUS WORK: Several state experiment stations started research on engineering aspects of cotton production about the time of the introduction of the row-crop tractor in the late 1920's. One of the early developments was the roll-type stripper harvester, developed in cooperation with the farm equipment industry. (3) At the same time, the industry was developing the picker-type harvester which was introduced in the early 1940's.

The availability of mechanical cotton harvesters after World War II revealed the need to mechanize all production operations from crop residue disposal through ginning. A regional research project, S-2, was initiated in 1947 to enhance the mechanization of cotton production. This project continued, with revisions, through 1969.

A number of noteworthy findings emanated from research under the S-2 project. Mechanization of cotton production progressed at a rapid rate. The percentage of the crop mechanically harvested increased from about 3% in 1947 to about 94% in 1967. Mechanical power replaced animal power almost 100% in this period. Many new chemicals were introduced for insect, disease, and weed control, and most of the equipment for their specialized application was developed by S-2 project workers. (8)

Basic information on the relationship of the micro-environment around the planted seed and planting methods has been obtained, and many improvements in planters and planting practices have been made. (7)

A number of improvements in mechanical harvesters have been made. Techniques of growing the crop for more efficient harvests have been developed, and some basic information on the physical characteristics of the plant as they relate to harvesting has been accumulated. (6) (9)

Although little, if any, systems analysis technique has been applied to engineering problems in cotton production, the simulation model for optimization of systems has been successfully applied to solve industrial and agricultural problems. A production model has been used successfully in solving production, harvesting and processing schedules for vegetables by Seabrook Farms. (10) Mills (2) used a production model to predict optimum harvesting dates for peanuts; and a grain handling problem similar to seed cotton handling problems was solved by a simulation model. (1)

ORGANIZATION: A Regional Technical Committee shall outline the area of work, assign responsibility, review progress, issue reports and publications, and perform other administrative tasks associated with the regional

project. This committee shall consist of one technical representative from each cooperating state and one member from the cooperating USDA agency. A chairman shall be elected each year from the state members.

An Executive Committee composed of three; namely, one state Technical Committee member from each of the three areas, Southeast, Mid-South and Southwest shall serve in the interim between meetings of the Technical Committee and to perform other duties as delegated or assigned by the Technical Committee. They shall be elected by the Technical Committee. The Directors' Representative, the Technical Committee member from the Agricultural Engineering Research Division of USDA, a representative from CSRS, and the Coordinator may meet with the Executive Committee as non-voting members. The Chairman of the Technical Committee shall serve as Chairman of the Executive Committee.

An Agricultural Engineer, with the title of Coordinator, shall assist in certain phases of the research and in performing the coordinating functions of the Technical Committee. He shall maintain liaison and promote cooperative effort among the several states and USDA agencies through correspondence, personal visits and the transmission of pertinent information. He shall also

participate in the assembly of data, the preparation of annual reports, and the preparation of manuscripts for publication. The Coordinator shall serve as secretary to both the Technical and Executive Committees. His salary and expenses shall be met jointly by the Agricultural Engineering Division, ARS, USDA, and the Mississippi Agricultural Experiment Station.

SIGNATURES:

Recommended for approval:

_______________________________ _______________

Southern Directors' Representative Date

_______________________________ _______________

Chairman, Southern Directors Association Date

_______________________________ _______________

Chairman, Committee of Nine Date

Approved:

_______________________________ _______________

Administrator, CSRS Date

ATTACHMENTS:

Project Leaders:

Alabama: W. T. Dumas, Agricultural Engineer, Auburn

Arizona: H. N. Stapleton, Agricultural Engineer, Tucson

Arkansas: E. J. Matthews, Agricultural Engineer, Fayetteville

Georgia: J. G. Futral, Agricultural Engineer, Experiment

Louisiana: C. H. Thomas, Agricultural Engineer, Baton Rouge

Mississippi: E. B. Willimason, Agricultural Engineer, ARS AERD, & DBES, Stoneville

North Carolina: H. D. Bowen, Agricultural Engineer, Raleigh

Oklahoma: J. G. Porterfield, Agricultural Engineer, Stillwater

South Carolina: T. H. Garner, Agricultural Engineer, Clemson

Tennessee: J. A. Mullins, Agricultural Engineer, Jackson

Texas: L. H. Wilkes, Agricultural Engineer, College Station
E. B. Hudspeth, Agricultural Engineer, ARS, AERD, Lubbock

AERD, ARS: W. M. Bruce, Agricultural Engineer, Beltsville, Maryland

AERD, ARS: R. F. Colwick (Coordinator), Agricultural Engineer, State College, Mississippi

Literature Cited:

1. Bouland, H. D., 1967. Truck Queues at Country Grain Elevators. Operations Research 15:649-659.

2. Mills, W. T., 1961. Effective Heat Units as a System for Predicting Optimum Time for Harvesting Peanuts. Paper presented, Amer. Soc. of Agricultural Engineers Annual Meeting, Dec.

3. Smith, H. P. et. al. 1935. Progress in Mechanical Cotton Harvesting. Texas Agr. Exp. Station, Bulletin 511, September.

4. Stapleton, H. N. and K. K. Barnes. 1967 Data needs for Agricultural Systems Analysis. ASAE Transactions Vol. 10, No. 3.

5. Starbird, I. R. and F. K. Hines, 1967. 1965 Supplement to Costs of Producing Cotton in the United States, 1964. USDA Agr. Economic Report No. 99, September.

6. Technical Committee Members, S-2 and W-24, 1953. Mechanization of Cotton Production. Sou. Coop. Series Bul. No. 33, June.

7. ________________, 1957. Planting in the Mechanization of Cotton Production. Sou. Coop. Series Bul. No. 49, February.

8. ________________, 1960. Weed Control Equipment and Methods. Sou. Coop. Series Bul. No. 71, April.

9. ________________, 1965. Mechanized Harvesting of Cotton Sou. Coop. Series Bul. No. 100, March.

10. Thornthwaite, C. W., 1953. Operations Research in Agriculture. Opn. Research, p. 133-138.

11. U.S. Dept. of Agriculture, 1967. Crop Reports. Statistical Reporting Service, Washington, D.C.

Anticipated Resources:

Cooperating Agency, Location,		Est. SMY/Yr.
Alabama AES, Auburn		.50
Arizona AES, Tucson		.50
Arkansas AES, Fayetteville		.50
Georgia ES, Experiment		1.10
Louisiana AES, Baton Rouge		1.30
Mississippi AES:	State College	.20
	Stoneville	.30
North Carolina AES, Raleigh		1.50
Oklahoma AES, Stillwater & Chickasha		1.25
South Carolina AES, Clemson		.20
Tennessee AES, Jackson		.30
Texas AES, College Station		.50
AERD, ARS:	State College, Miss.	1.50
	Stoneville, Miss.	3.00
	Lubbock, Texas	1.00
	Tucson, Arizona	.60
	Total	14.25

a